

EFFECT OF QUANTITY AND METHOD OF APPLICATION OF SULPHUR AT DIFFERENT GROWTH STAGES IN IMPROVING THE QUALITY OF QPM AND NUTRIENT AVAILABILITY IN THE SOIL

NAVATHA. N¹, VANL. K. P², SRINIVAS. A³ & SURENDRA BABU. P⁴

^{1,2,3} Professor, Department of Agronomy, Professor Jayashankar Telangana State
Agricultural University, Rajendranagar, Hyderabad, India

⁴Department of Soil Science and chemistry, Professor Jayashankar Telangana State
Agricultural University, Rajendranagar, Hyderabad, India

ABSTRACT

In order to investigate the effect of sulphur levels and method of application on sulphur uptake in quality protein maize (QPM) at 30, 60, 90 and harvest stage (grain and stover) and available nutrients in soil, an experiment was conducted. This experiment was conducted with factorial arrangement based on randomised block design with three replications, four factors of sulphur levels (S₁:-10 kg ha⁻¹, S₂:-20 kg ha⁻¹, S₃:-30 kg ha⁻¹ and S₄:-40 kg ha⁻¹) and two method of sulphur application (M₁: 100% basal as single dose; M₂: Two split applications: - 50% each at basal and knee height stage) in Quality Protein Maize (QPM) production in an experimental field located at the College farm, Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad, India. The result of experiment showed that the sulphur uptake increased progressively with sulphur levels. Among the four sulphur levels, significantly higher sulphur uptake was observed with 40 kg S ha⁻¹. In method of application, sulphur uptake was found superior in split application at basal and at knee height stage, compared to basal application of sulphur at 30, 60, 90 DAS at harvest stage. The application of sulphur had not shown any significant effect on the available nitrogen, phosphorous and potassium status of the soil. Sulphur status in the soil increased from its initial condition in all the treatments, with increase in sulphur levels. However, the available sulphur content in soil significantly increased in the treatment applied with 40 kg S ha⁻¹ and the lowest with 10 kg S ha⁻¹. The available sulphur content in soil varied from its initial status in different time of application of sulphur.

KEYWORDS: Available, Nutrients, Soil, Sulphur, Uptake & Quality Protein Maize

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INTRODUCTION

Maize (*Zea mays* L.) is an important feed and food crop after wheat and rice, and ranks third in the world and also in India. It is known as a most important profitable crop of great agro-financial value. It is grown widely in subtropical, tropical and temperate region in the world.

Maize is an exhaustive crop that absorbs huge quantity of nutrient from the soil during different stages of growth. Sulphur is an essential nutrient for animal and all plant life. Plant takes up approximately the same amount of sulphur as that of phosphorus (Tandon, 1991). Sulphur importance is increasing in all regions of the world and in some areas, it is second to nitrogen in importance. Sulphur deficiencies are occurring with greater frequency in more locations throughout the world. As a result of its importance, many agriculturists are now classifying it as

fourth major nutrient.

Sulphur is essential for synthesis of the amino acids, a component of vitamin A and activates certain enzyme systems in plants (Havlin., 2004). Under S deficient conditions, the efficiency of applied NPK fertilizers may be seriously affected and crop yield levels may not be sustainable (Ahmad., 1994). Continuous removal of S from soils through plant uptake has led to widespread S deficiency and affected soil S budget (Aulakh., 2003) all over the world. It was reported that sugar crops yield increase at 60 Kg ha⁻¹ sulphur application in the form of gypsum and observed residual effects on the growth of the ratoon crop (Mathew., 2003). Fertilizers, which contain sulphur as a combining ingredient, are being replaced with high analysis fertilizers that are low in sulphur. S fertilization increases oil, protein and glucosinolate in seed (Malhi., 2007). Nitrogen use efficiency also improves with S and thus maintains adequate fatty acid quality and oil level (Fismes., 2000). Sulphur deficiency has become a major constraint in crop production in coarse textured soils (Takkar., 1989). Introduction of high yielding crop varieties, intensive and multiple cropping and the decreased use of farmyard manures seem to have lead to a wide occurrence of S deficiency. Sulphur deficiency has been reported from over 70 countries worldwide (Tandon., 1991). Crop yield and quality can be effected with inadequate S supply as S is necessary for the structure of methionine and cystein, protein certain amino acids, and enzyme synthesis.

Updating of sulphur recommendation to maize is currently focused, therefore, it would be a very opportune time to look at split applications of sulphur, to determine if timing should be considered for farmers growing maize. In general practice, sulphur is applied in a single basal dose, while N is applied in two split doses. This application practice may create an imbalance between S and N at later growth stages as more than 50% of sulphur applied to soil may leach out, because of the strong leaching behaviour of sulphate like nitrate. (Ahmad *et al.*, 1998). In view of this fact, the present study was designed to assess the effect of different sulphur levels and method of application on sulphur uptake by dry matter, grain and available nutrients in soil.

MATERIAL AND METHODS

Experimental Site, Climate and Soil

The field experiment entitled “Studies on sulphur levels and method of application on sulphur uptake at 30, 60, 90 DAS and at harvest stage in QPM and available nutrients in soil after harvest” was conducted at College farm, Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad situated at 17°19' N latitude and 78°23' E longitude at an altitude of 542.3 m above mean sea level. The experimental soil was sandy loam in texture, neutral in reaction, low in organic carbon, available nitrogen and sulphur, medium in available phosphorous and high in potassium. Experiment was carried out with four sulphur levels (S₁: 10 kg ha⁻¹, S₂: 20 kg ha⁻¹, S₃: 30 kg ha⁻¹ and S₄: 40 kg ha⁻¹) as first factor and method of sulphur application (M₁: 100% basal as single dose; M₂: Two split applications:-50% each at basal and knee height stage) as second factor, comprising eight treatment combination, laid out in randomized block design with factorial concept replicated thrice.

Quality protein maize hybrid (HQPM-1) was sown in *kharif*- 2014 at a spacing of 60 cm x 20 cm. A uniform dose of 80 kg P₂O₅ as diammonium phosphate, potassium @ 80 kg ha⁻¹ as murate of potash was applied to all the treatments. Entire dose of phosphorous and half of potassium were applied at the time of sowing. Nitrogen was applied as per the treatments through urea in three equal splits (at basal, knee-height and tasseling stages). Similarly, the remaining potassium and nitrogen was top dressed at tasseling stage. Sulphur was applied through gypsum in two methods of applications i.e. M₁- 100% basal application at time of sowing; M₂- two split applications:-50% each at basal and knee height stage as per

the treatments.

RESULTS AND DISCUSSIONS

Sulphur Uptake in Plant at 30, 60, 90 DAS

The data pertaining to sulphur uptake at 30, 60, 90 DAS in the plant was significantly influenced by levels and method of application of sulphur, as shown in Table 1.

Sulphur uptake in plant at 30, 60, 90 DAS was significantly increased with increasing levels of sulphur from 10 kg S ha⁻¹ to 40 kg S ha⁻¹. At 30 DAS, sulphur uptake was significantly influenced by sulphur levels. Among the four sulphur levels, the higher sulphur uptake was observed with 40 kg S ha⁻¹ (7.27 kg ha⁻¹), significantly superior to sulphur uptake by 30 kg S ha⁻¹ (7.16 kg ha⁻¹), while lower sulphur uptake of 6.86 kg ha⁻¹ recorded with 10 kg sulphur application. Sulphur uptake by plant was non-significant among the method of application at early stages of crop growth.

Similarly, at 60 DAS, sulphur uptake was significantly influenced by sulphur levels, where maximum sulphur uptake (13.3 kg ha⁻¹) was observed with 40 kg S ha⁻¹ followed by 30 kg ha⁻¹ (12.9 kg ha⁻¹) and minimum sulphur uptake of 11.9 kg ha⁻¹ was noticed with 10 kg sulphur application. Split application of sulphur i.e. 50% as basal and 50% at knee height stage resulted in maximum sulphur uptake (12.8 kg ha⁻¹) at 60 DAS, followed by 100% basal application of sulphur (12.5 kg ha⁻¹).

The data at 90 DAS on sulphur uptake revealed that, as the crop advanced to 90 days, the sulphur uptake increased progressively with sulphur levels. Among the four sulphur levels, significantly higher sulphur uptake of 16.6 kg ha⁻¹ was observed with 40 kg S ha⁻¹, significantly superior over the sulphur uptake obtained with 30 kg S ha⁻¹ (16.2 kg ha⁻¹), 20 kg S ha⁻¹ (15.8 kg ha⁻¹) and 10 kg S ha⁻¹ (15.4 kg ha⁻¹). In method of application, sulphur uptake was found superior in split application as basal and at knee height stage (16.1 kg ha⁻¹) compared to basal application of sulphur (15.8 kg ha⁻¹) at 90 DAS.

Sulphur uptake by Grain and Stover at Harvest Stage

The data pertaining to sulphur uptake by grain and stover was significantly influenced by levels and method of application of sulphur as shown in Table 2.

Sulphur uptake increased with increased levels of sulphur. Application of 40 kg S ha⁻¹ had recorded significantly more sulphur uptake (12.1 kg ha⁻¹) by grain, followed by 30 kg ha⁻¹ (10.1 kg ha⁻¹), 20 kg ha⁻¹ (9.30 kg ha⁻¹) and minimum sulphur uptake obtained with 10 kg S ha⁻¹ (8.65 kg ha⁻¹). The per cent increase in sulphur uptake was 7.5%, 16.7% and 39.8% with 20 kg ha⁻¹, 30 kg ha⁻¹ and 40 kg ha⁻¹ over 10 kg ha⁻¹.

Higher sulphur uptake recorded by stover (9.46 kg ha⁻¹) with 40 kg S ha⁻¹, followed by 30 kg ha⁻¹ (8.70 kg ha⁻¹), 20 kg ha⁻¹ (8.01 kg ha⁻¹) and lower sulphur uptake obtained with 10 kg S ha⁻¹ (7.20 kg ha⁻¹) by stover. The per cent of sulphur uptake was higher with 40 kg S ha⁻¹ (31.3%), followed by 30 kg S ha⁻¹ (20.8%) and 20 kg S ha⁻¹ (11.2%), compared to when maize plants were applied with 10 kg S ha⁻¹.

Similarly, among different method of application, split application of sulphur as 50% as basal and 50% at knee height stage (M₂) showed significant effect on sulphur uptake, indicating increased sulphur uptake (10.4 kg ha⁻¹) by grain and (8.69 kg ha⁻¹) by stover, significantly higher than (M₁) basal application (9.65 kg ha⁻¹) by grain and (8 kg ha⁻¹) by stover.

Interaction effect between levels and method of application of sulphur was found non-significant on the sulphur uptake of quality protein maize hybrid.

Application of sulphur significantly increased the sulphur uptake by maize grain and stover. Increase in sulphur uptake may be attributed to increase in S concentration in plant and dry matter yield Sakal *et al.*, 2000 and Srinivasrao *et al.*, 2010.

Split application of sulphur (50% S at sowing + 50% S top dressed at knee height stage) was more effective for improving plant sulphur nutrient status, i.e. increasing S accumulation and concentration in shoot and maize kernel. These results are in conformity with the findings of Habtegebrail and Singh 2006 and Wang *et al.* (2014).

POST- HARVEST SOIL ANALYSIS

Available N, P and K

Results pertaining to available nitrogen, phosphorous and potassium in soil after harvest of the crop was not significantly influenced by levels and method of application of sulphur. Interaction effect of levels and method of application of sulphur in quality protein maize was also found to be non- significant as presented in the Table 3.

The application of sulphur had not shown any significant effect on the available nitrogen, phosphorous and potassium status of the soil. These results are also in line with the findings of Ramanathan and Ramanathan (1985).

Available Sulphur

The available sulphur content in soil after harvest of quality protein maize was analysed statistically and represented in table 3. Sulphur status in the soil increased from its initial condition in all the treatments, with increase in sulphur levels. However, the available sulphur content in soil significantly increased in the treatment applied with 40 kg S ha⁻¹ (12.5 kg ha⁻¹) and the lowest with 10 kg S ha⁻¹ (10.7 kg ha⁻¹).

At harvest stage, the available sulphur content in soil varied from its initial status in different time of application of sulphur. However, significantly higher available sulphur content (11.8 kg ha⁻¹) in soil after harvest of the crop was shown in the M₂ treatment i.e. split application of sulphur as basal and at knee height stage compared to lower sulphur status in the soil, after harvest of the crop (11.4 kg ha⁻¹) with M₁ (basal application) of sulphur.

Interaction effect between levels and method of application of sulphur was found non-significant with the available sulphur in soil after harvest of the crop. Increased levels of sulphur influenced the sulphur status in the soil. Similar results were found by Mahesh (2001) and Choudhary *et al.* (2013).

CONCLUSIONS

It is concluded based on the above findings, in respect of the sulphur uptake by QP Maize at 30, 60, 90 and harvest stages that, the best results were achieved with application of sulphur @ 40 kg ha⁻¹ along with split method of application. Hence, it can be recommended for sustaining nutrient availability in quality protein maize.

Table 1: Sulphur Uptake (kg ha⁻¹) by Plant of QPM as Influenced by Sulphur Levels and Method of Application

Sulphur Levels (S)	30DAS			60 DAS			90 DAS		
	Basal (M ₁)	Split (M ₂)	Mean	Basal (M ₁)	Split (M ₂)	Mean	Basal (M ₁)	Split (M ₂)	Mean
S ₁ : 10 kg ha ⁻¹	6.97	6.76	6.86	11.9	12.0	11.9	15.3	15.6	15.4
S ₂ : 20 kg ha ⁻¹	7.10	7.00	7.05	12.3	12.6	12.4	15.7	15.9	15.8

Table 1: Contd.,

S ₃ : 30 kg ha ⁻¹	7.23	7.10	7.16	12.7	13.1	12.9	16.0	16.4	16.2
S ₄ : 40 kg ha ⁻¹	7.33	7.22	7.27	13.2	13.5	13.3	16.4	16.7	16.6
Mean	7.16	7.02		12.5	12.8		15.8	16.1	
	SEm±	CD (p=0.05)		SEm±	CD (p=0.05)		SEm±	CD (p=0.05)	
S	0.08	0.23		0.12	0.35		0.12	0.35	
M	0.06	NS		0.09	0.26		0.08	0.23	
S x M	0.12	NS		0.18	NS		0.17	NS	

M₁: 100% basal application; M₂: 50% basal+50% at knee height stage

Table 2: Sulphur Uptake (kg ha⁻¹) by Grain and Stover of QPM as Influenced by Sulphur Levels and Method of Application

Sulphur Levels (S)	Grain			Stover		
	Basal (M ₁)	Split (M ₂)	Mean	Basal (M ₁)	Split (M ₂)	Mean
S ₁ : 10 kg ha ⁻¹	8.06	9.23	8.65	6.60	7.80	7.20
S ₂ : 20 kg ha ⁻¹	8.83	9.76	9.30	7.70	8.33	8.01
S ₃ : 30 kg ha ⁻¹	10.0	10.2	10.1	8.46	8.93	8.70
S ₄ : 40 kg ha ⁻¹	11.7	12.5	12.1	9.23	9.70	9.46
Mean	9.65	10.4		8.00	8.69	
	SEm±	CD (p=0.05)		SEm±	CD (p=0.05)	
S	0.30	0.88		0.22	0.63	
M	0.20	0.61		0.15	0.43	
S x M	0.43	NS		0.31	NS	

M₁: 100% basal application; M₂: 50% basal+50% at knee height stage

Table 3: Available N, P₂O₅, K₂O (kg ha⁻¹) and S (mg kg⁻¹) in Soil after Harvest of the Crop Influenced by Sulphur Levels and Method of Application

Sulphur levels (S)	Available N			Available P ₂ O ₅			Available K ₂ O			Available S		
	Basal (M ₁)	Split (M ₂)	Mean	Basal (M ₁)	Split (M ₂)	Mean	Basal (M ₁)	Split (M ₂)	Mean	Basal (M ₁)	Split (M ₂)	Mean
S ₁ : 10 kg ha ⁻¹	276	282	279	39.3	39.6	39.5	374	375	374	10.5	10.9	10.7
S ₂ : 20 kg ha ⁻¹	285	288	287	40.0	40.5	40.2	375	375	375	11.0	11.5	11.2
S ₃ : 30 kg ha ⁻¹	290	293	292	40.7	40.8	40.8	376	377	376	11.8	12.0	11.9
S ₄ : 40 kg ha ⁻¹	295	300	297	41.0	41.6	41.3	377	378	377	12.2	12.8	12.5
Mean	287	291		40.3	40.6		375	376		11.4	11.8	
	SEm±	CD (p=0.05)		SEm±	CD (p=0.05)		SEm±	CD (p=0.05)		SEm±	CD (p=0.05)	
S	7.56	NS		2.33	NS		13.7	NS		0.13	0.38	
M	5.35	NS		1.66	NS		9.7	NS		0.09	0.26	
S x M	10.7	NS		3.33	NS		19.4	NS		0.18	NS	

M₁: 100% basal application; M₂: 50% basal+50% at knee height stage

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